CLAIMS

What is claimed is:

1. A rotating device, comprising:
   a) a plurality of first comb fingers extending from a first structure;
   b) a plurality of second comb fingers extending from a second structure, wherein said first comb fingers are interdigitated with said second comb fingers in an engagement
   c) a rotating element attached to a rotatable flexure disposed along an axis, wherein said rotating element is mechanically coupled to said first structure and hence said first comb fingers; and
   d) a biasing element coupled to said rotating element, for causing said first comb fingers along with said rotating element to undergo a controlled angular displacement from said engagement about said axis;

   wherein said first comb fingers along with said rotating element can further rotate about said axis, once displaced from said engagement.

2. The rotating device of claim 1 further comprising a capacitance sensor, coupled between said second comb fingers and said first comb fingers.

3. The rotating device of claim 2 further comprising a feedback mechanism coupled to said capacitance sensor and said biasing element.

4. The rotating device of claim 1 further comprising a voltage source coupled between said second comb fingers and said first comb fingers.

5. The rotating device of claim 4, wherein a voltage between the first and second comb fingers provided by the voltage source produces a force between the first and second comb fingers that tends to displace the first and second comb fingers along with said rotating element the back toward said engagement.

6. The rotating device of claim 4 further comprising a position sensor.

7. The rotating device of claim 6, further comprising a feedback mechanism coupled between the position sensor and voltage source.

8. The rotating device of claim 6, wherein the position sensor includes one or more of the following:
one or more gap closing electrodes,
a second plurality of first comb fingers coupled to the rotating element and a second plurality of second comb fingers that interdigitate with the first comb fingers in the second plurality,
a capacitance sensor coupled between the first plurality of comb fingers and the second plurality of comb fingers
a piezoresistive strain gauge,
a piezoelectric sensor,
an optical sensor.

9. The rotating device of claim 1 wherein said biasing element exerts a time-varying biasing force on said rotating element.

10. The rotating device of claim 1 wherein said biasing element exerts a constant biasing force on said rotating element.

11. The rotating device of claim 1 wherein said rotatable flexure is attached to a substrate.

12. The rotating device of claim 1 wherein said rotatable flexure comprises a stress-bearing material carrying a residual stress gradient, whereby upon releasing said residual stress gradient, said stress-bearing material causes said first comb fingers along with said rotating element to undergo said controlled angular displacement about said axis.

13. The rotating device of claim 11 wherein said substrate comprises a material selected from the group consisting of single-crystalline silicon, poly-crystalline silicon, single-crystalline silicon-germanium, poly-crystalline silicon-germanium, ceramic, silicon-oxide, silicon-nitride, chrome, aluminum, nickel, and gold.

14. The rotating device of claim 1 wherein said rotatable flexure comprises an element selected from the group consisting of torsional flexures with rectangular, I-shaped, or T-shaped cross-section, cantilever-like flexures, serpentine flexures, and pin-and-staple type hinges.

15. The rotating device of claim 1 wherein said second comb fingers and said first comb fingers comprise a material selected from the group consisting of single-crystalline silicon, poly-crystalline silicon, amorphous silicon, ceramic, glass, single-crystalline silicon-germanium, poly-crystalline silicon-germanium, nickel, and nickel alloy.

16. The rotating device of claim 1 wherein said second comb fingers are electrically isolated from said first comb fingers.

17. The rotating device of claim 1 wherein said rotating element is made of a material selected from the group consisting of single-crystalline silicon, poly-crystalline silicon, amorphous silicon, ceramic, glass, single-crystalline silicon-germanium, poly-crystalline silicon-germanium, nickel, and nickel alloy gold, aluminum, and chromium.

18. The rotating device of claim 1 wherein said rotating element comprises one or more reflective surfaces.

19. The rotating device of claim 1, wherein the device is employed in an optical switch.

20. The rotating device of claim 1 wherein said biasing element includes one or more of the following:
a magnetic material attached to the rotating element,
a current carrying coil attached to the rotating element,
one or more gap-closing electrodes attached to the rotating element,
a piezoelectric mechanism coupled to said rotating element,
a thermal bimorph actuator coupled to the rotating element,
a spring-loaded element coupled to the rotating element,
a stress-bearing material carrying a residual stress gradient, or
a second plurality of first comb fingers coupled to the rotating element and a second plurality of second comb

fingers that interdigitate with the first comb fingers in the second plurality.

21. The rotating device of claim 20 further comprising a capacitance sensor coupled between said second comb fingers and said first comb fingers.

22. The rotating device of claim 21 further comprising a feedback mechanism coupled to said capacitance sensor and said biasing element.

23. The rotating device of claim 20 further comprising a voltage source coupled between said second comb fingers and said first comb fingers.

24. The rotating device of claim 23 further comprising a position sensor to sense the position of the rotating element.

25. The rotating device of claim 24, further comprising a feedback mechanism coupled between the position sensor and voltage source.

26. The rotating device of claim 24, wherein the position sensor includes one or more of the following:
one or more gap closing electrodes,
a second plurality of first comb fingers coupled to the rotating element and a second plurality of second comb fingers that interdigitate with the first comb fingers in the second plurality,
a capacitance sensor coupled between the first plurality of comb fingers and the second plurality of comb fingers
a piezoresistive strain gauge,
a piezoelectric sensor, or

an optical sensor.

27. The rotating device of claim 20 wherein said biasing element produces a time-varying biasing force.

28. The rotating device of claim 20 wherein said biasing element produces a constant biasing force.

29. The rotating device of claim 1, further comprising:

e) a frame having a third structure coupled to the rotatable flexure;

f) a plurality of third comb fingers extending from the third structure

g) a second rotatable flexure coupled to the frame such that the frame can rotate about a second axis;

h) a plurality of fourth comb fingers coupled to a fourth structure, wherein said third comb fingers are interdigitated with said fourth comb fingers in an engagement.

30. The device of claim 29, wherein the device is employed in an optical switch.

31. A rotating device, comprising:

a) a plurality of first comb fingers extending from a first structure;

b) a plurality of second comb fingers extending from a second structure, wherein said first comb fingers are self-aligned and interdigitated with said second comb fingers in an engagement

c) a rotating element attached to a rotatable flexure disposed along an axis, wherein said rotating element is mechanically coupled to said first structure and hence said first comb fingers; and

d) a biasing element coupled to said rotating element, for causing said first comb fingers along with said

rotating element to undergo a controlled angular displacement from said engagement about said axis;

wherein said first comb fingers along with said rotating element can further rotate about said axis, once displaced from said engagement.

32. The rotating device of claim 31 further comprising a capacitance sensor, coupled between said second comb fingers and said first comb fingers.

33. The rotating device of claim 32 further comprising a feedback mechanism coupled to said capacitance sensor and said biasing element.

34. The rotating device of claim 31 further comprising a voltage source coupled between said second comb fingers and said first comb fingers.

35. The rotating device of claim 34, wherein a voltage between the first and second comb fingers provided by the voltage source produces a force between the first and second comb fingers that tends to displace the first and second comb fingers along with said rotating element the back toward said engagement.

36. The rotating device of claim 34 further comprising a position sensor.

37. The rotating device of claim 36, further comprising a feedback mechanism coupled between the position sensor and voltage source.

38. The rotating device of claim 36, wherein the position sensor includes one or more of the following:
one or more gap closing electrodes,
a second plurality of first comb fingers coupled to the rotating element and a second plurality of second comb

fingers that interdigitate with the first comb fingers in the second plurality,

a capacitance sensor coupled between the first plurality of comb fingers and the second plurality of comb fingers

a piezoresistive strain gauge,

a piezoelectric sensor,

an optical sensor.

39. The rotating device of claim 31 wherein said biasing element exerts a time-varying biasing force on said rotating element.

40. The rotating device of claim 31 wherein said biasing element exerts a constant biasing force on said rotating element.

41. The rotating device of claim 31 wherein said rotatable flexure is attached to a substrate.

42. The rotating device of claim 31 wherein said rotatable flexure comprises a stress-bearing material carrying a residual stress gradient, whereby upon releasing said residual stress gradient, said stress-bearing material causes said first comb fingers along with said rotating element to undergo said controlled angular displacement about said axis.

43. The rotating device of claim 41 wherein said substrate comprises a material selected from the group consisting of single-crystalline silicon, poly-crystalline silicon, single-crystalline silicon-germanium, poly-crystalline silicon-germanium, ceramic, silicon-oxide, silicon-nitride, chrome, aluminum, nickel, and gold.

44. The rotating device of claim 41 wherein said rotatable flexure comprises an element selected from the group consisting of torsional flexures with rectangular, I-shaped, or T-shaped cross-section, cantilever-like flexures, serpentine flexures, and pin-and-staple type hinges.

45. The rotating device of claim 41 wherein said second comb fingers and said first comb fingers comprise a material selected from the group consisting of single-crystalline silicon, poly-crystalline silicon, amorphous silicon, ceramic, glass, single-crystalline silicon-germanium, poly-crystalline silicon-germanium, nickel, and nickel alloy.

46. The rotating device of claim 41 wherein said second comb fingers are electrically isolated from said first comb fingers.

47. The rotating device of claim 41 wherein said rotating element is made of a material selected from the group consisting of single-crystalline silicon, poly-crystalline silicon, amorphous silicon, ceramic, glass, single-crystalline silicon-germanium, poly-crystalline silicon-germanium, nickel, and nickel alloy gold, aluminum, and chromium.

48. The rotating device of claim 41 wherein said rotating element comprises one or more reflective surfaces.

49. The rotating device of claim 41, wherein the device is employed in an optical switch.

50. The rotating device of claim 41 wherein said biasing element includes one or more of the following:

a magnetic material attached to the rotating element,
a current carrying coil attached to the rotating element,
one or more gap-closing electrodes attached to the rotating element,
a piezoelectric mechanism coupled to said rotating element,
a thermal bimorph actuator coupled to the rotating element,
a spring-loaded element coupled to the rotating element,
a stress-bearing material carrying a residual stress gradient, or
a second plurality of first comb fingers coupled to the rotating element and a second plurality of second comb fingers that interdigitate with the first comb fingers in the second plurality.

51. The rotating device of claim 50 further comprising a capacitance sensor coupled between said second comb fingers and said first comb fingers.

52. The rotating device of claim 51 further comprising a feedback mechanism coupled to said capacitance sensor and said biasing element.

53. The rotating device of claim 50 further comprising a voltage source coupled between said second comb fingers and said first comb fingers.

54. The rotating device of claim 53 further comprising a position sensor to sense the position of the rotating element.

55. The rotating device of claim 54, further comprising a feedback mechanism coupled between the position sensor and voltage source.

56. The rotating device of claim 54, wherein the position sensor includes one or more of the following:
one or more gap closing electrodes,
a second plurality of first comb fingers coupled to the rotating element and a second plurality of second comb fingers that interdigitate with the first comb fingers in the second plurality,
a capacitance sensor coupled between the first plurality of comb fingers and the second plurality of comb fingers
a piezoresistive strain gauge,
a piezoelectric sensor, or
an optical sensor.

57. The rotating device of claim 50 wherein said biasing element produces a time-varying biasing force.

58. The rotating device of claim 50 wherein said biasing element produces a constant biasing force.

59. The rotating device of claim 31, further comprising:
e) a frame having a third structure coupled to the rotatable flexure;
f) a plurality of third comb fingers extending from the third structure
g) a second rotatable flexure coupled to the frame such that the frame can rotate about a second axis;
h) a plurality of fourth comb fingers coupled to a fourth structure, wherein said third comb

fingers are self-aligned and interdigitated with said fourth comb fingers in an engagement.

60. The device of claim 59, wherein the device is employed in an optical switch.